

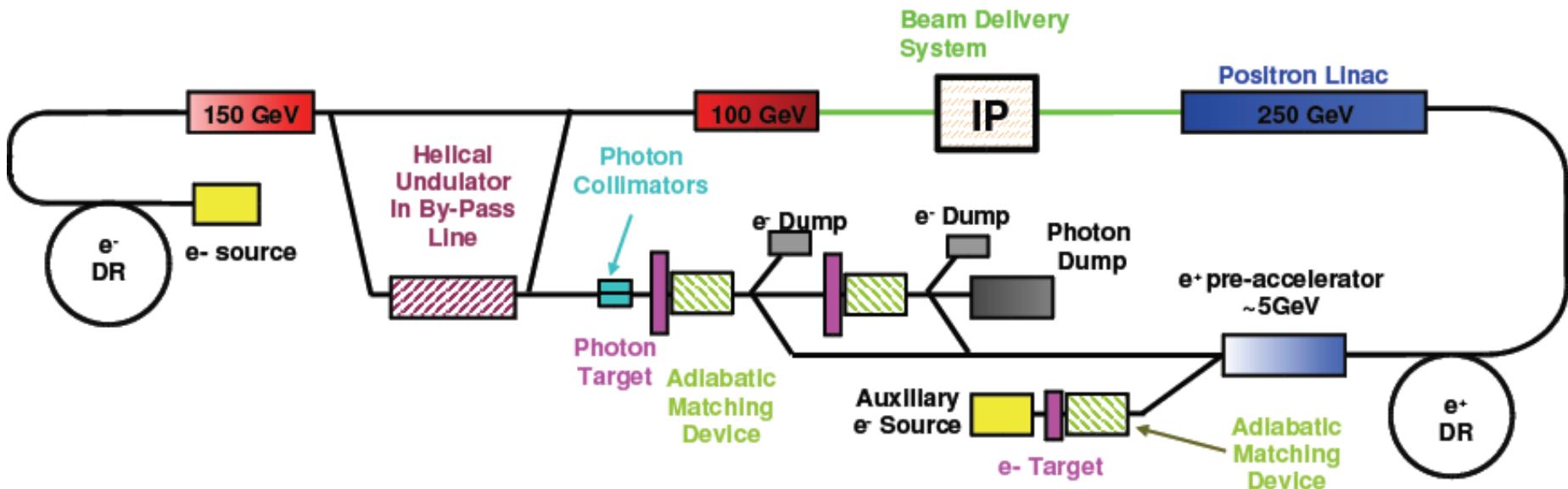
ILC Superconducting Magnets

V. Kashikhin for ILC Magnet Group

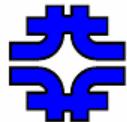
April 25, 2006

Superconducting Magnets

- Main Linac quadrupoles
- Beam Delivery System Magnets
- Positron Source solenoids
- Ring to Main Linac quadrupoles and solenoids
- Damping Ring wigglers

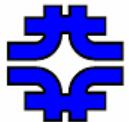


Main Linac Quadrupole



Beamline name (location of use)	Electron/positron Main Linac
Quantity required	$2*214 = 428$
Magnet type (main harmonic)	Quadrupole
Integrated Strength of field	36 T
Effective length or max/min field constraint ?	0.6m
Layout [center(X,Y,Z), Slot length]	0.66m
Sagitta for dipoles (value, tolerance - if required)	N/A
Stage 2 (1 TeV CM) requirements	same
Field strength	54 T/m
Effective length or max/min field constraint ?	0.6m

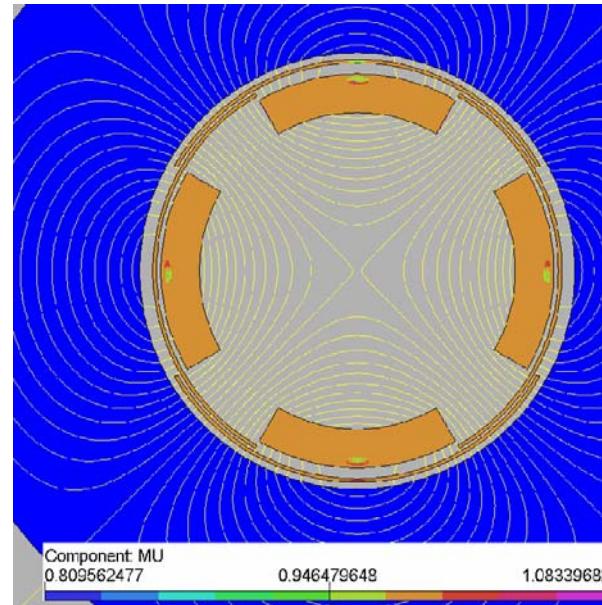
Bore diameter or full gap (x,y apertures)	dia=90mm(pipe dia=78mm)
Reference radius (to define 'good field' region)	5 mm
Normal/superconducting?	Superconducting
Field Tolerances:	
on main component (for magnets in strings)	2e-5 (<1ms), 1e-3(>0.2sec)
on multipole components	<3.e-4 at reference radius
Limit on maximum field/pole tip field ?	
Additional magnetic component(s) (e.g., trim coils if integrated with main harmonic)	skew, dipole corrector (if integrated)
Integrated Strength of field(s)	0.1 Tm



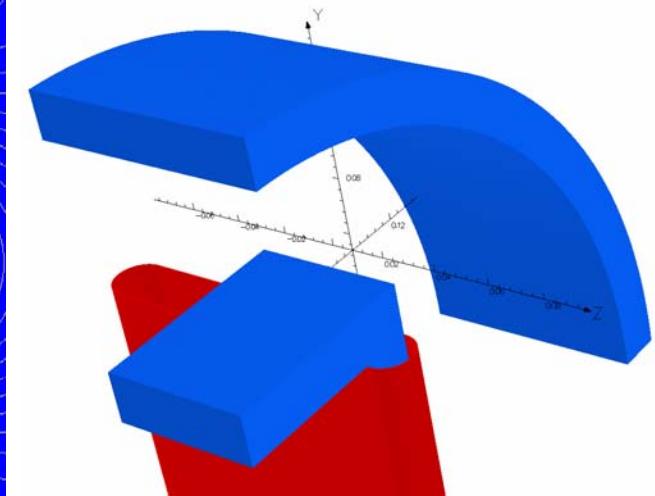
Magnets for ILC Main Linac

ILC Main Linac Quadrupole

- Low current (50 –100 A)
- Aperture 78 mm
- Gradient > 50 T/m
- Length ~ 0.6 m
- Adjustable field -20%
- Magnetic center stability 1 μ m
- Low fringing fields 1-10 μ T
- Possible issues:
 - magnetic center motion (SC magnetization, Lorentz forces, mechanics, iron saturation and hysteresis, etc)
 - fringing field trapped in SCRF at cooling down and operation



2-4 μ m magnetic center displacement in quadrupole with dipole correctors

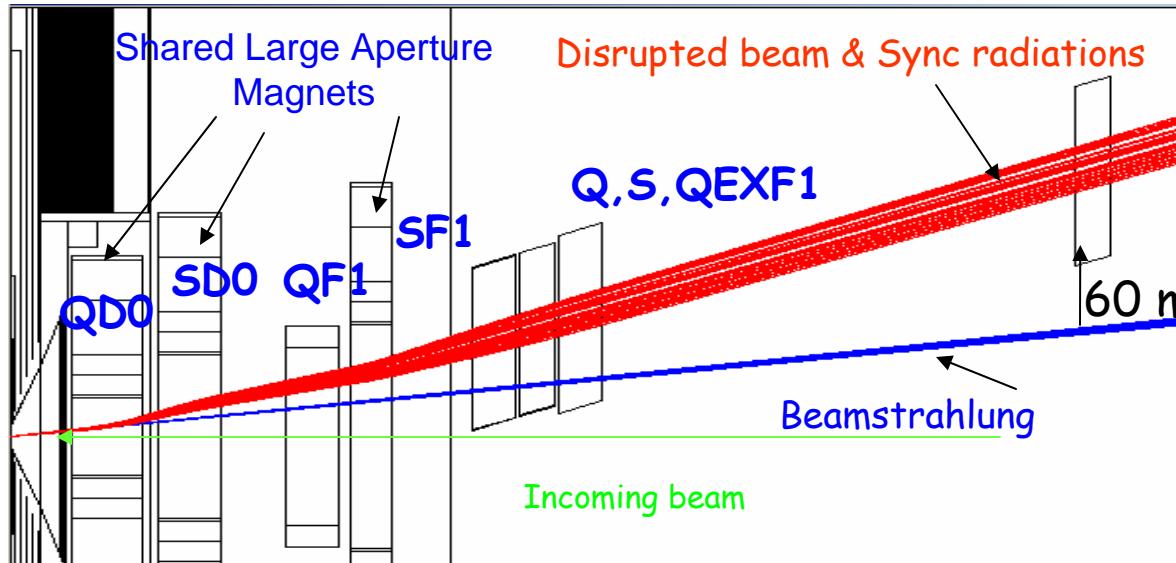


Dipole corrector 3D field calculations showed the 0.3% integrated field homogeneity at 30 mm aperture radius for this 150mm length corrector

Proposal:

1. Separate main quadrupole and dipole correctors to eliminate coupling effects
2. Move quadrupole+corrector in space between cryomodules

Magnets for ILC IR



LHC IR Quadrupole

Meeting SLAC, 25-26 April, 2006

Design options

- NbTi LHC IR Quadrupole (2 m models 215 T/m built and tested)
- Nb₃Sn Quadrupole (LARP type)
but small filament size superconductor (bronze technology) to reduce superconductor magnetization effects

ILC superconducting magnets

2 mrad IR Quadrupole

- Aperture 70 mm
- Effective length 2.5 m
- Gradient 160 T/m
- Magnetic center stability 1-5 μ m
- Girder with 50 nm steps
- Removable magnet system for Detector exchange

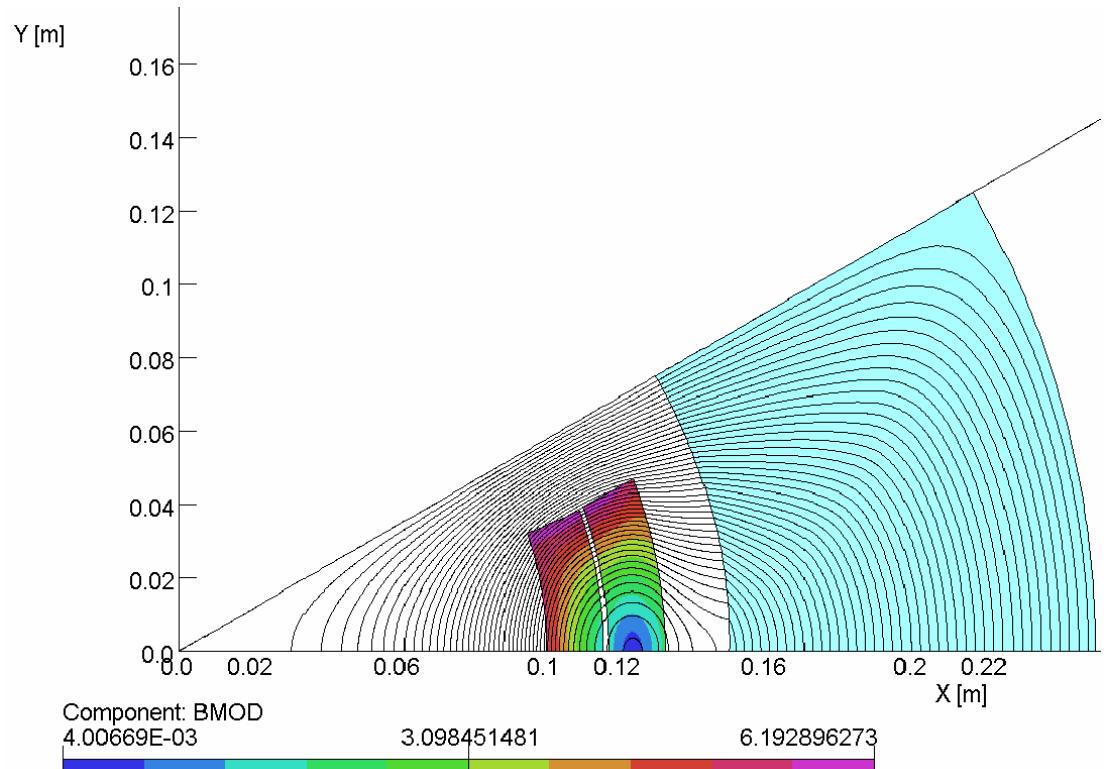
Possible issues:

1. Magnetic center motion (SC magnetization, Lorentz forces, mechanics, iron saturation and hysteresis, etc)
2. Detector solenoidal field
3. Superconducting magnets moving carriage

V.Kashikhin

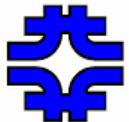
IR Large Bore Sextupole

Maximum field at 95 mm radius	4.3 T
Sextupole strength	510 T/m ²
Effective length	2 m
Good field area diameter	10 mm
Clear aperture radius	95 mm
Coil inner radius	100 mm
Coil outer radius	133 mm
Iron core inner radius	150 mm
Iron core outer radius	250 mm
Collar structure thickness	15 mm
Beam pipe thickness	2.5 mm
Losses at 4.2 K	< 10 W



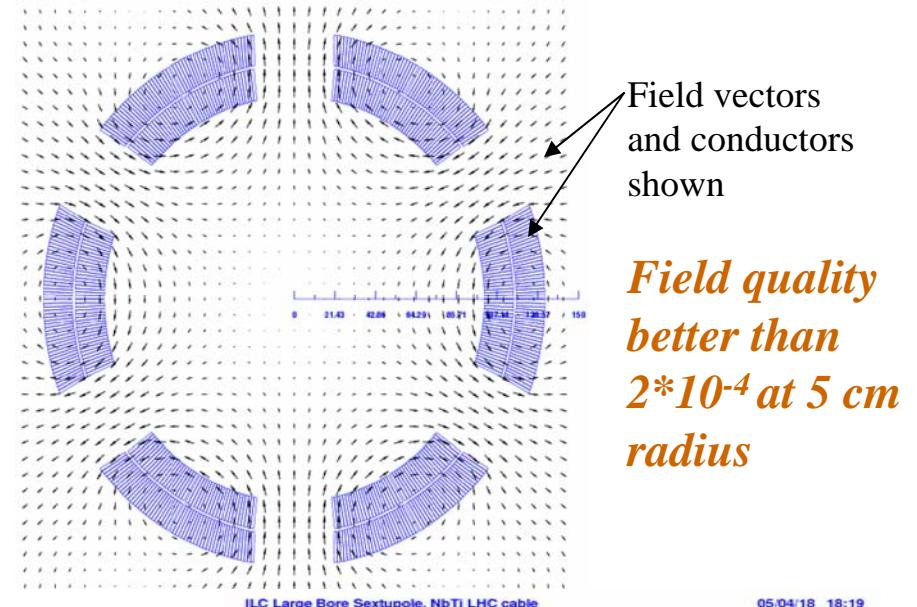
Shell type coil sextupole with cold iron core

Design close to LHC IR Quadrupoles

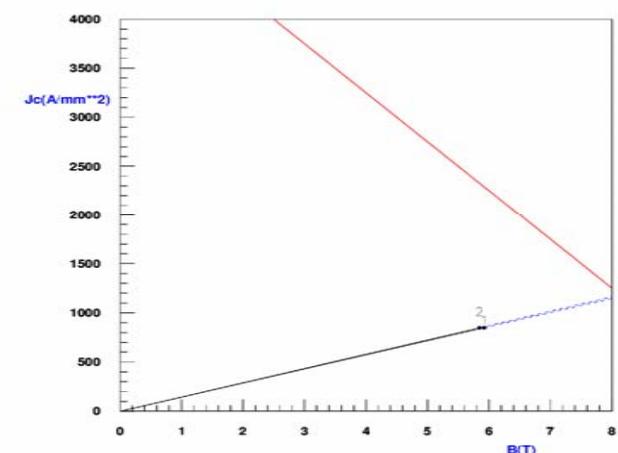


Sextupole 2D Magnetic Design

Coil ampere-turns	343 kA
Current	7 kA
Calculated strength	519.2 T/m²
Coil maximum field	6.2 T
Iron core field (max)	3.8 T
Field energy	376 kJ/m
Lorentz force, Fx	56.5 t/m
Lorentz force, Fy	-83.2 t/m
Number of turns	22(inner) + 27(outer)
NbTi Superconducting cable	LHC IR inner
J_c at B=5 T, 4.2	2750 A/mm²
Strand diameter	0.808 mm

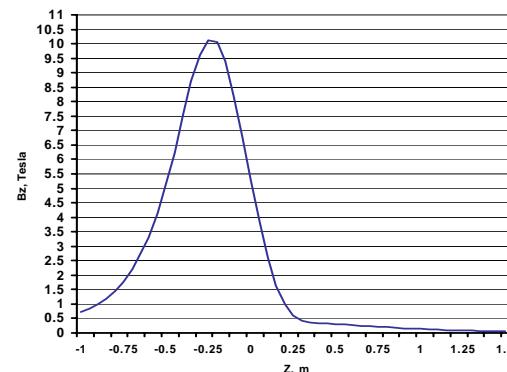
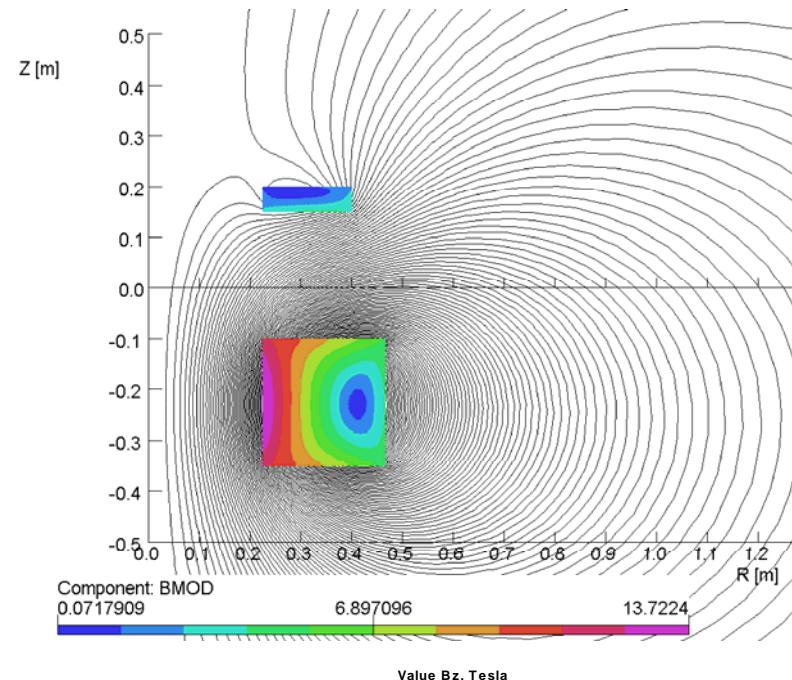
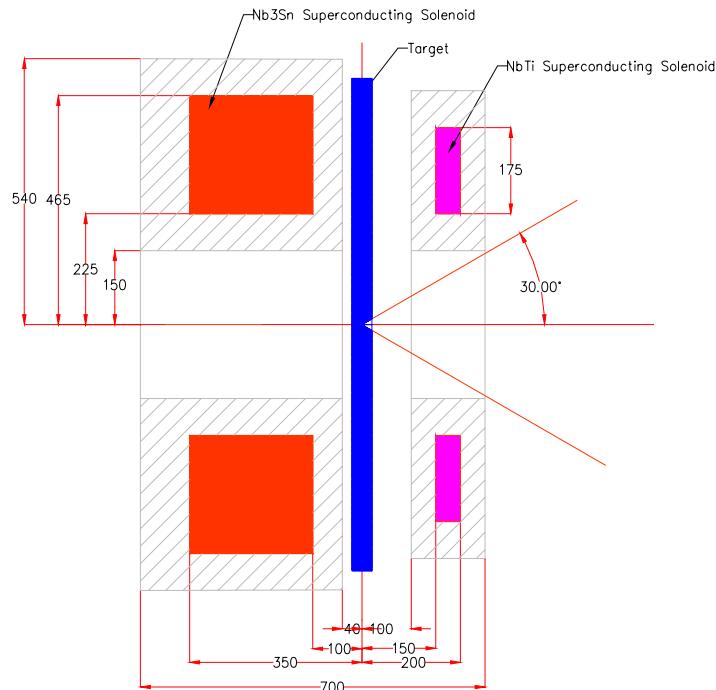


Field quality better than 2×10^{-4} at 5 cm radius

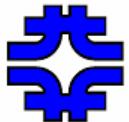


Large LHC cable margin provides design space for future cable and geometry optimization

Positron Source Solenoids



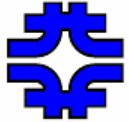
Field in the center of target B_z, T	5.31
Maximum coil field, T	13.7
Main coil ampere-turns, kA	6000
Small coil ampere-turns, kA	-875
Total stored energy, MJ	5.125



Large bore and long length solenoids possible candidates to be superconducting

TAPA+TA PB+KA S	1-38	solenoid	5 kG	36 cm (bore)	1.3(length)	6 x1.27 m (7.62m long)
TAPA+TA PB+KA S	38-125	solenoid	5 kG	31 cm (bore)	4.3(length)	9x4.3 m (38.7m long)
PPA	125-400	solenoid	2.5 kG	31 cm (bore)	4.3(length)	24x4.3 m (103.2m long)

Total length 149.52 m



All superconducting magnets are feasible.

R&D and prototyping are needed to confirm the specified performance and cost estimation.

Main Linac quadrupoles: HGQ and LGQ, magnetic center stability, trim coils, position in cryomodule

Beam Delivery System Magnets: magnetic center stability, heat load, girder, solenoidal field

Positron Source solenoids: RT or SC

Ring to Main Linac quadrupoles and solenoids: main linac LGQ

Damping Ring wigglers: NbTi or Nb3Sn